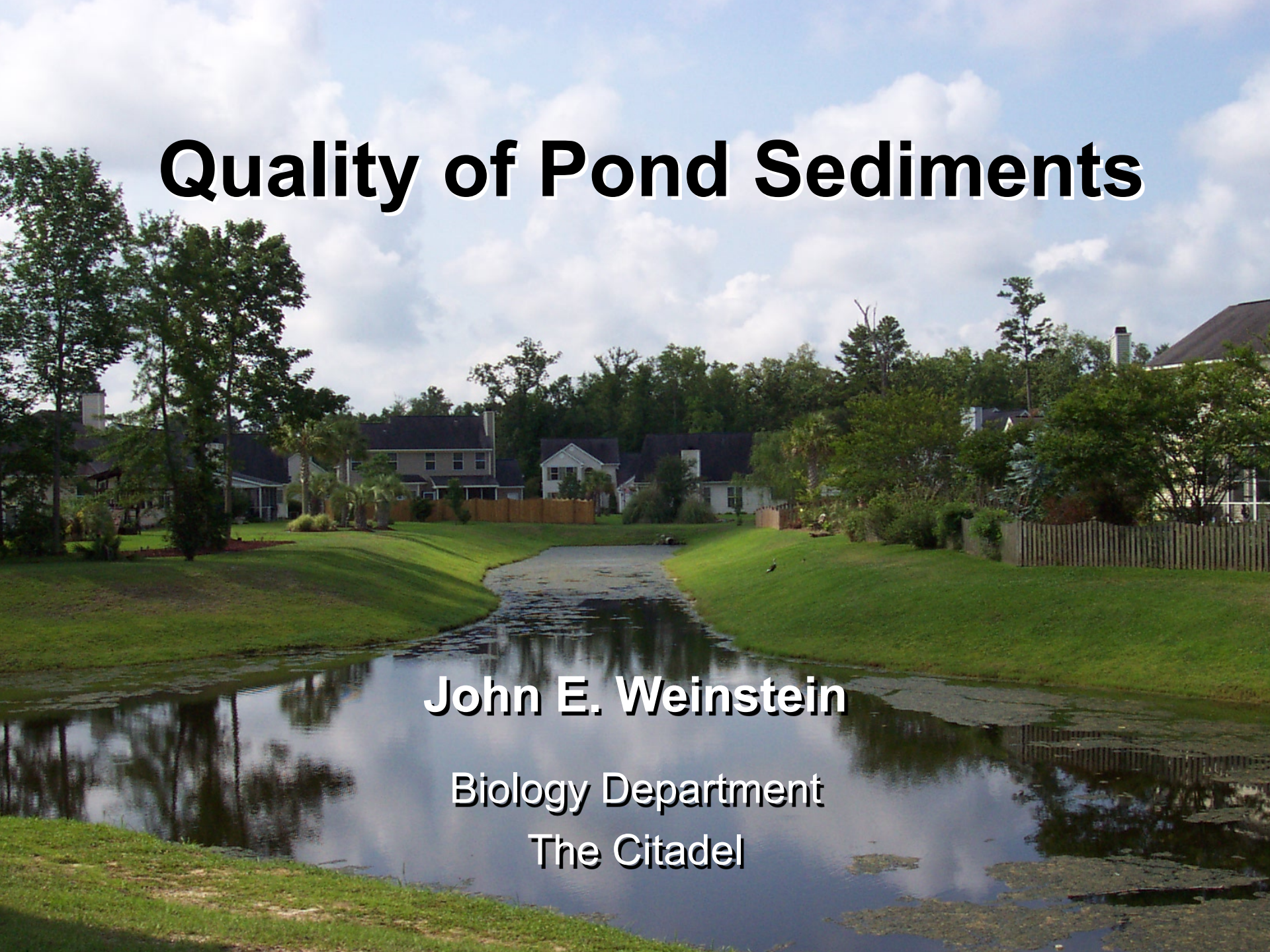
Quality of Pond Sediments



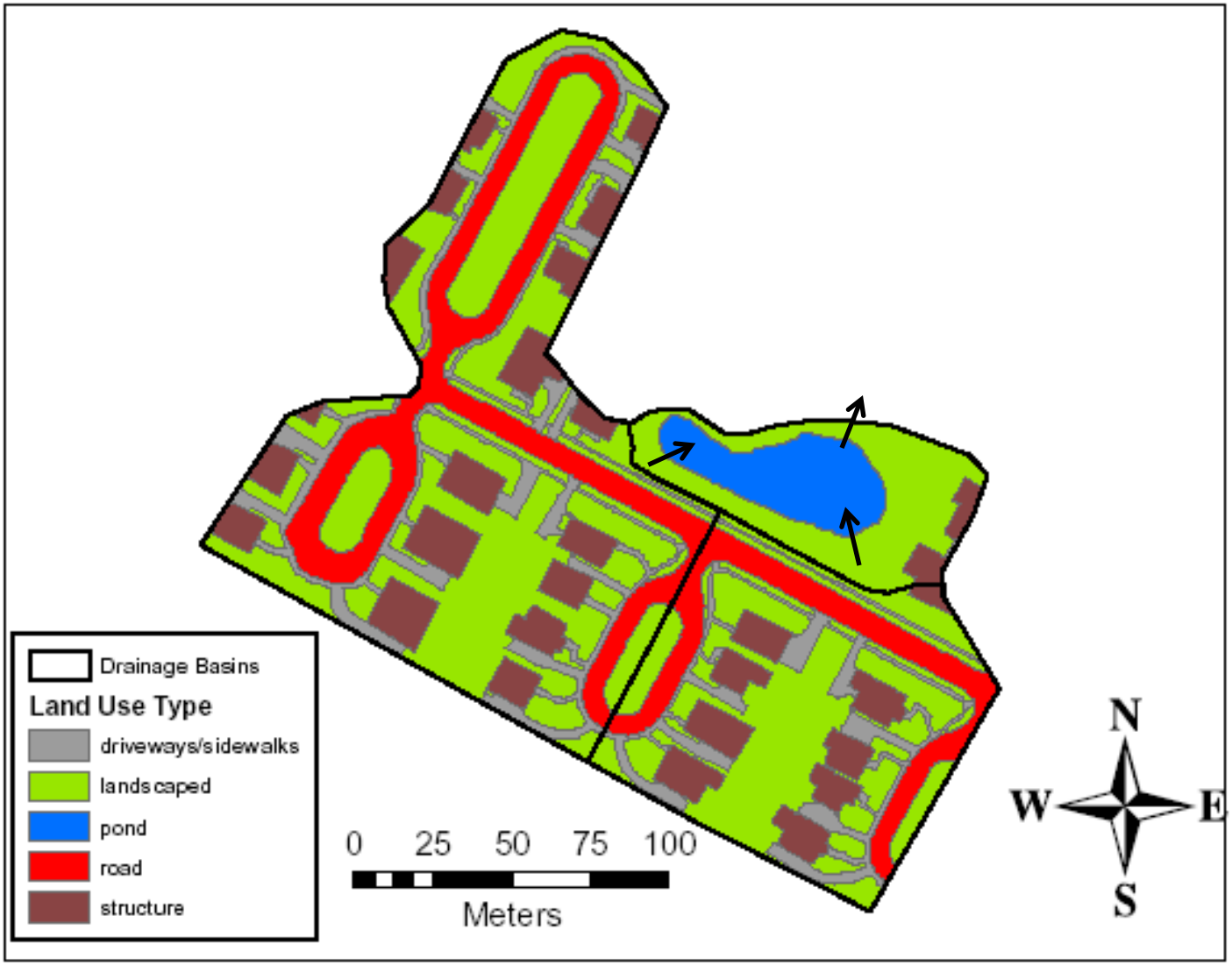
John E. Weinstein

Biology Department
The Citadel

Stormwater Detention Ponds

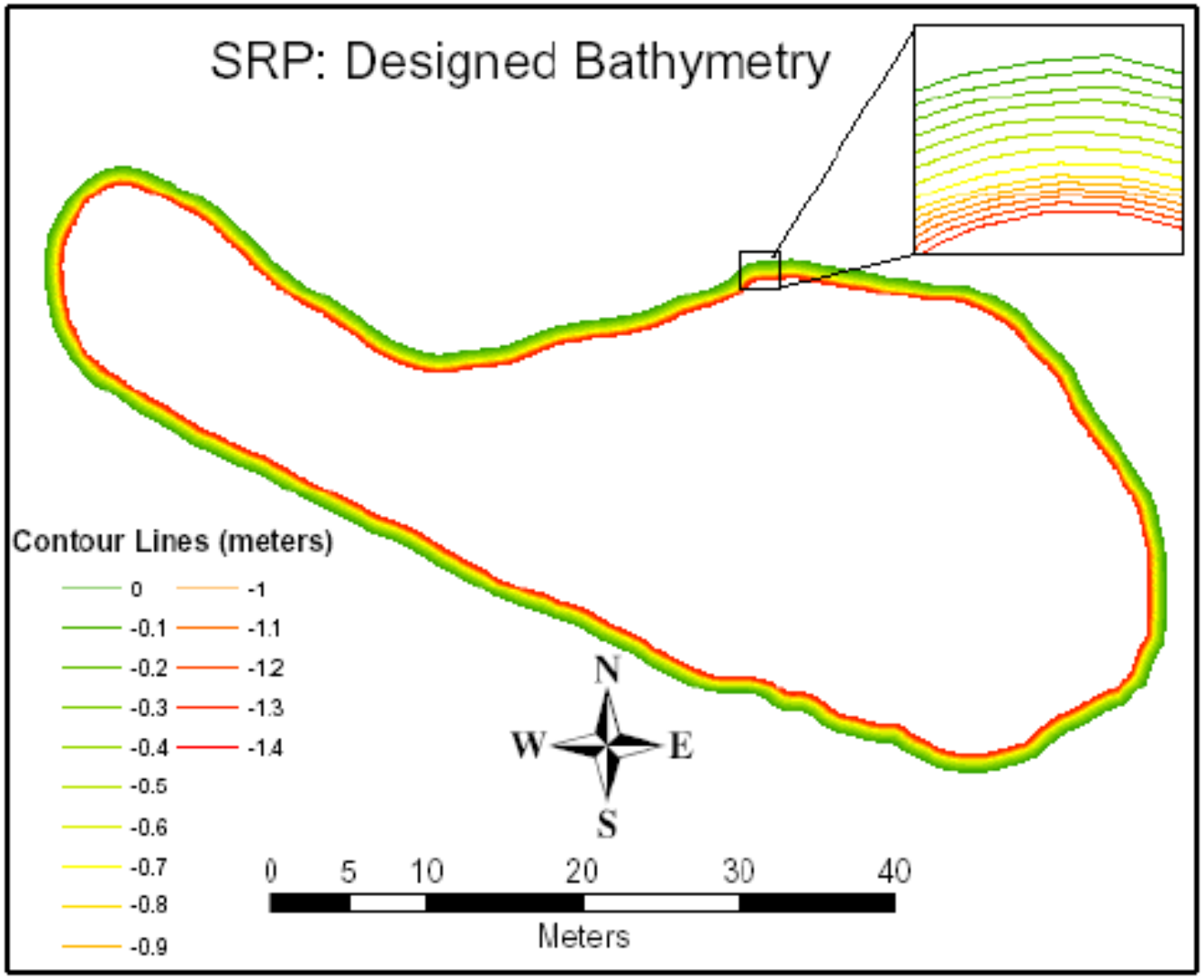
- Common BMP
  - enhance aesthetics and property values, open space
- Protect natural receiving waters
  - flood control structures
  - settling basins
- Trap suspended sediment
  - sediment from pond watershed

Map depicting land cover in typical single residential pond, Daniel Island, SC



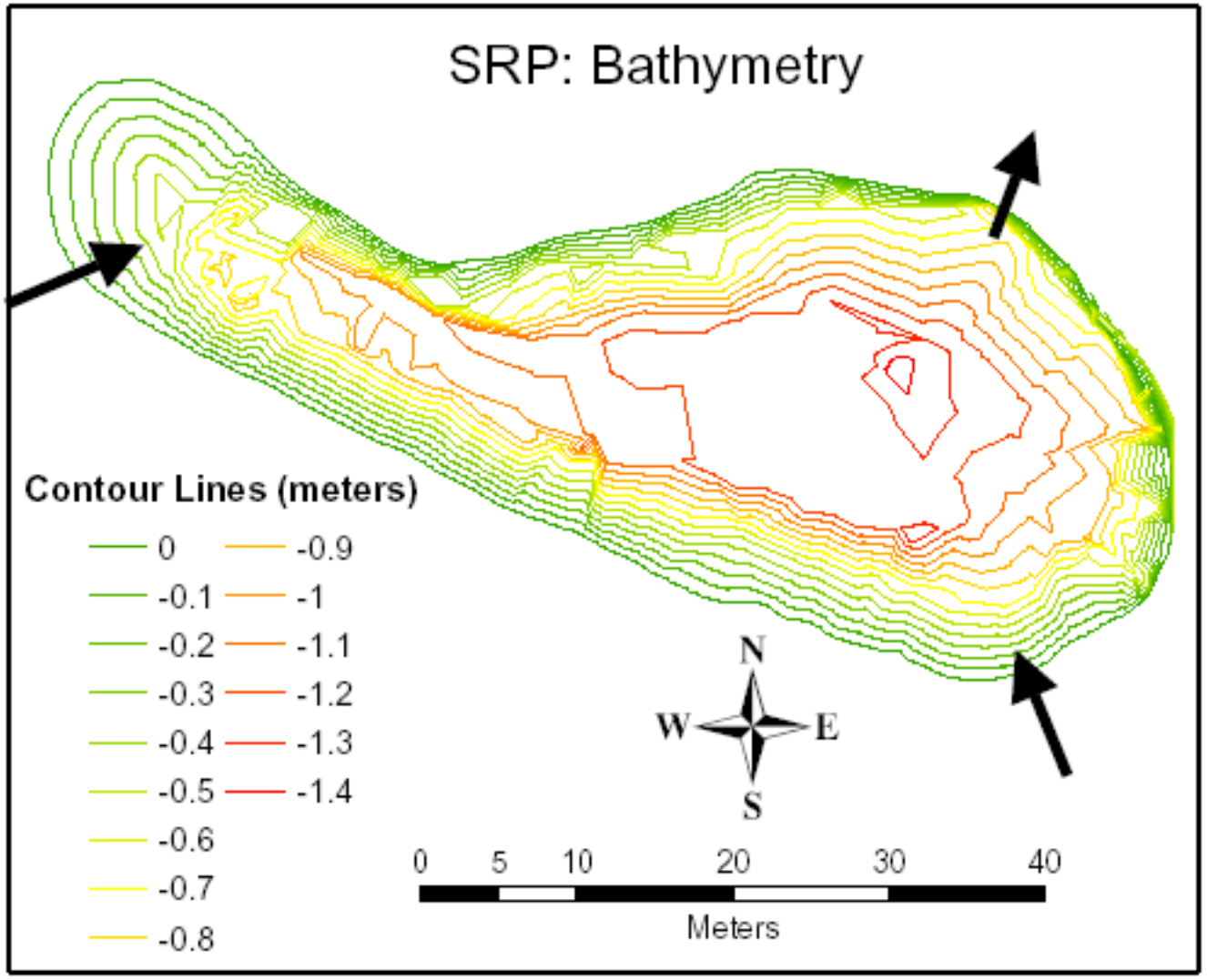
Messersmith, 2007

Designed bathymetry of single residential pond by Thomas and Hutton Engineering (permitted 1999)



Messersmith, 2007

Measured pond bathymetry of single residential pond (2006)



Messersmith, 2007

Consequences of Sedimentation

- Reduction in efficiency
- Chemical contaminants bound to sediment
- Periodic sediment removal recommended
- No requirement of testing for chemical or biological sediment contaminants
- On-site disposal of excavated sediments may pose risks to humans
- Sediment remaining *in situ* may pose risks to wildlife

Critical Questions

- How contaminated are bottom sediments in typical coastal stormwater ponds?
- Do these contaminant levels have the potential to pose ecological and human health risks?

Stormwater Pond Sediment Project - Methodology

- Sampled 18 Ponds
  - June 2007
  - Classified based on land use
- Analyzed Sediments
  - PAHs
  - Metals
  - Pesticides
  - PBDEs
  - Fecal Coliforms

Stormwater Ponds

Reference

Willow Swamp Road (FMNF) (R1)

Dill Plantation (R2)

Golf Course

Indigo Run (80)

Arrow Head C.C. (62)

Traditions G.C. (57)

Residential-LD

Daniel Island (89)

Pawleys Place (31)

Whitehall Plantation (109)

Ashton Glenn (24)

Ricefields (38)

Residential-HD

Sable Palm Apts. (7)

Cantebury (44)

Commercial

Wal-Mart, J.I. (70)

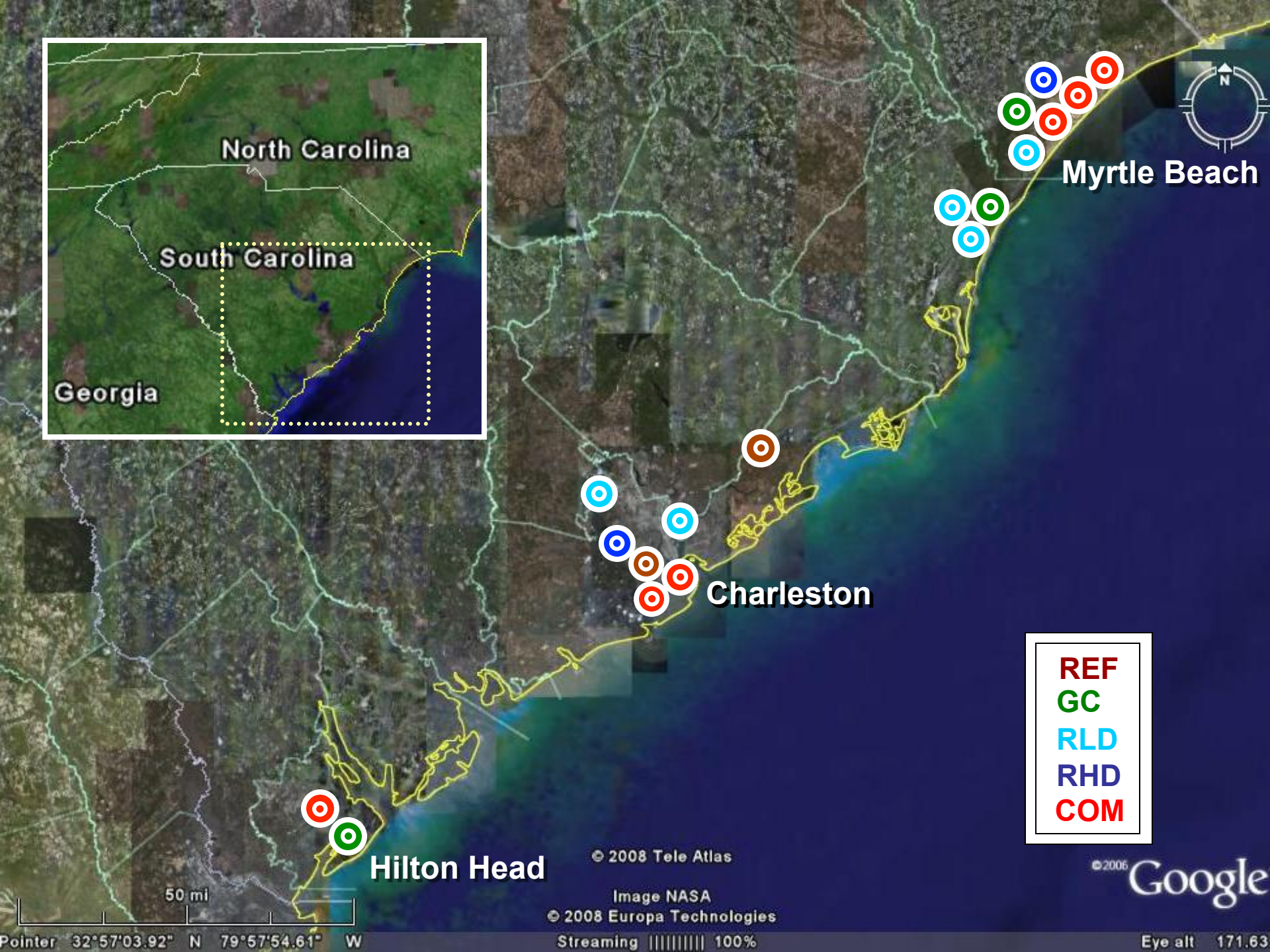
Tanger Outlets, Bluffton (48)

M.B. Chevrolet (26)

Riverland Woods (68)

Toys R Us, M.B. (83)

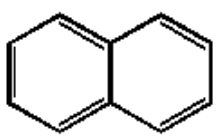
NASCAR Speed Track (87)


North Carolina
South Carolina
Georgia
Myrtle Beach
Charleston
Hilton Head
REF
GC
RLD
RHD
COM
© 2008 Tele Atlas
Image NASA
© 2008 Europa Technologies
©2006 Google
50 mi
Pointer 32°57'03.92" N 79°57'54.61" W
Streaming 100%
Eye alt 171.63

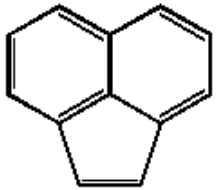
Polycyclic Aromatic Hydrocarbons

NASCAR Cafe, Myrtle Beach, SC

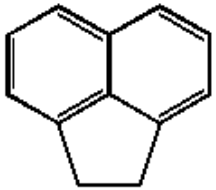
Polycyclic Aromatic Hydrocarbons (PAHs)



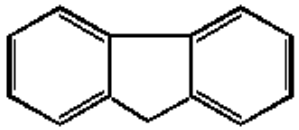
Naphthalene



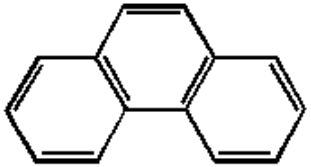
Acenaphthylene



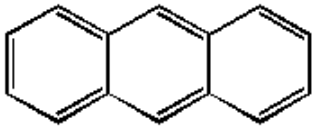
Acenaphthene



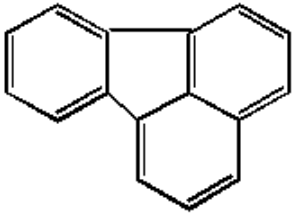
Fluorene



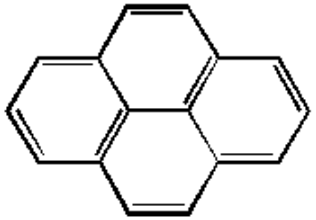
Phenanthrene



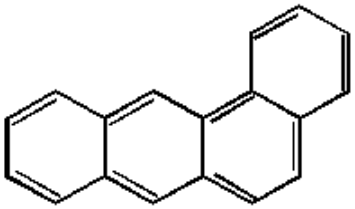
Anthracene



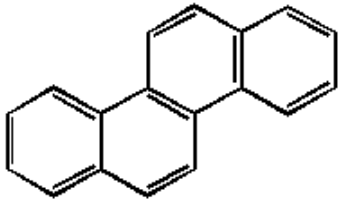
Fluoranthene



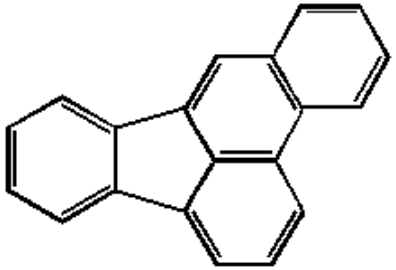
Pyrene



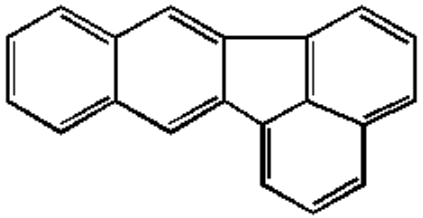
Benzo(a)anthracene



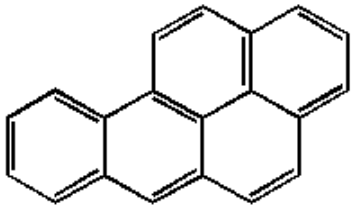
Chrysene



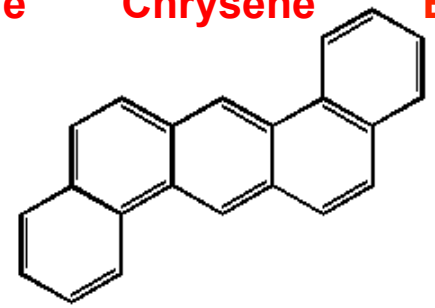
Benzo(b)fluoranthene



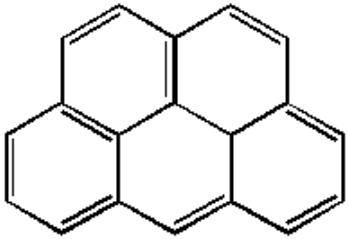
Benzo(k)fluoranthene



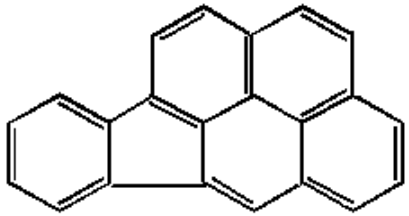
Benzo(a)pyrene



Dibenz(a,h)anthracene

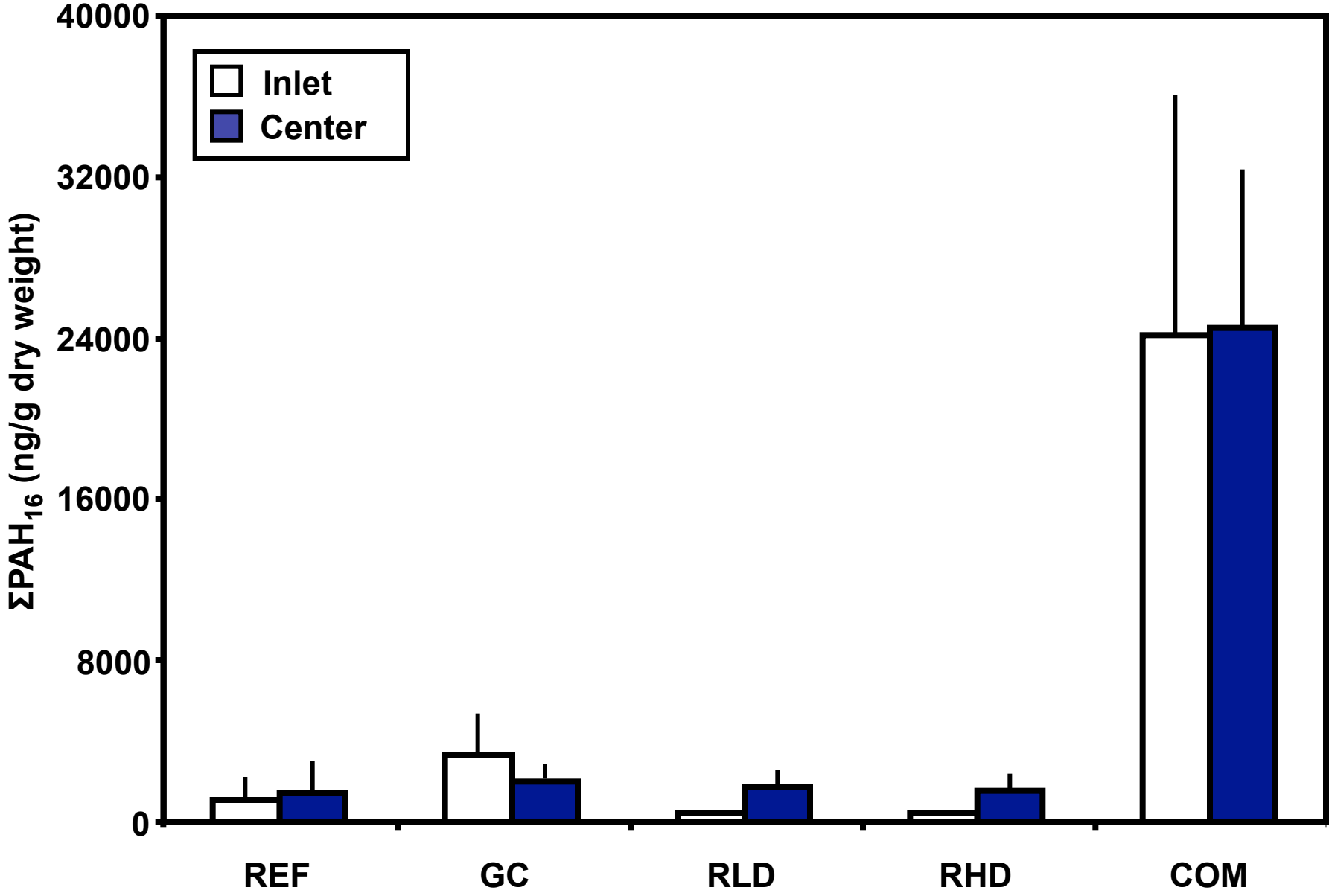


Benzo(g,h,i)perylene

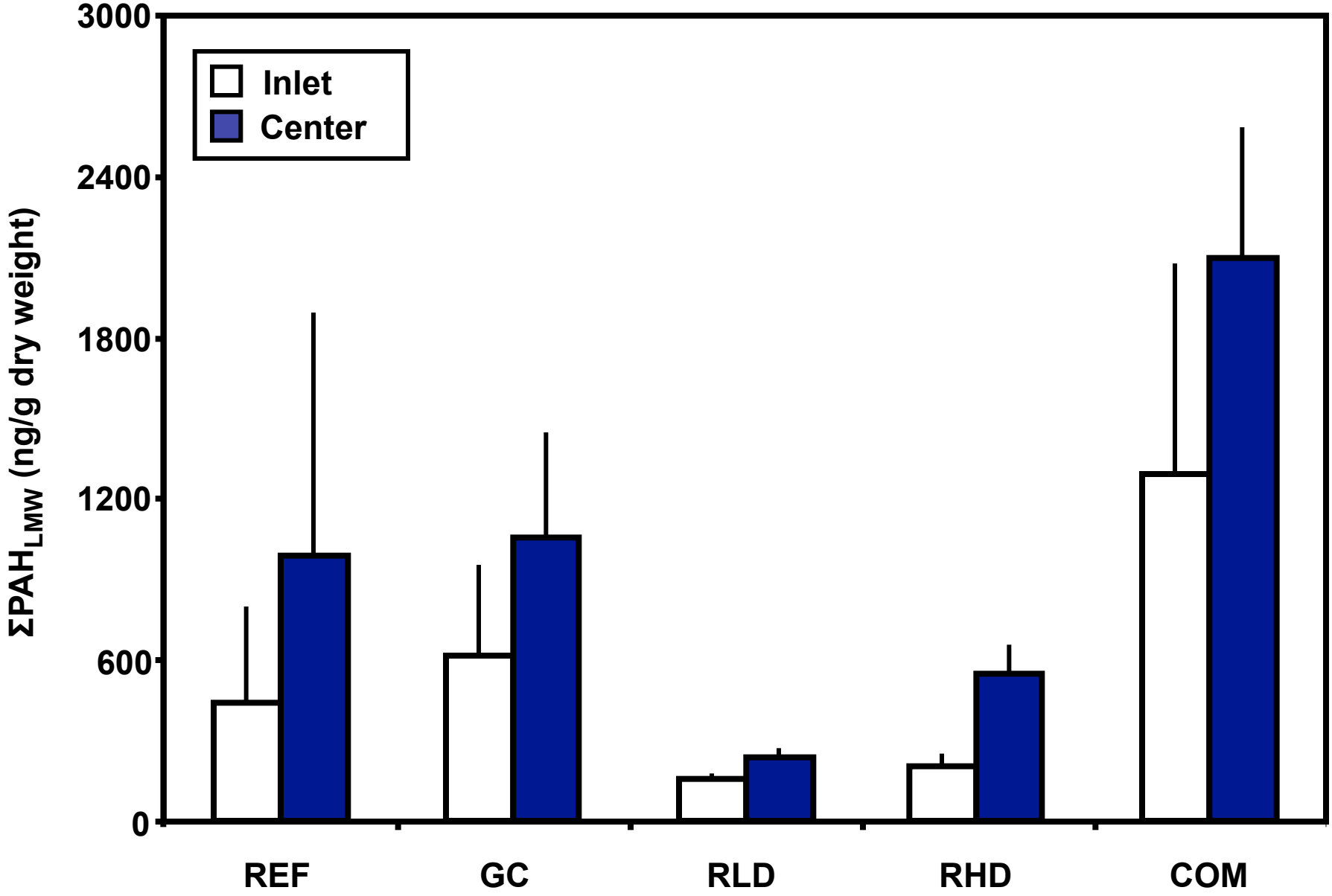


Indeno(1,2,3-cd)pyrene

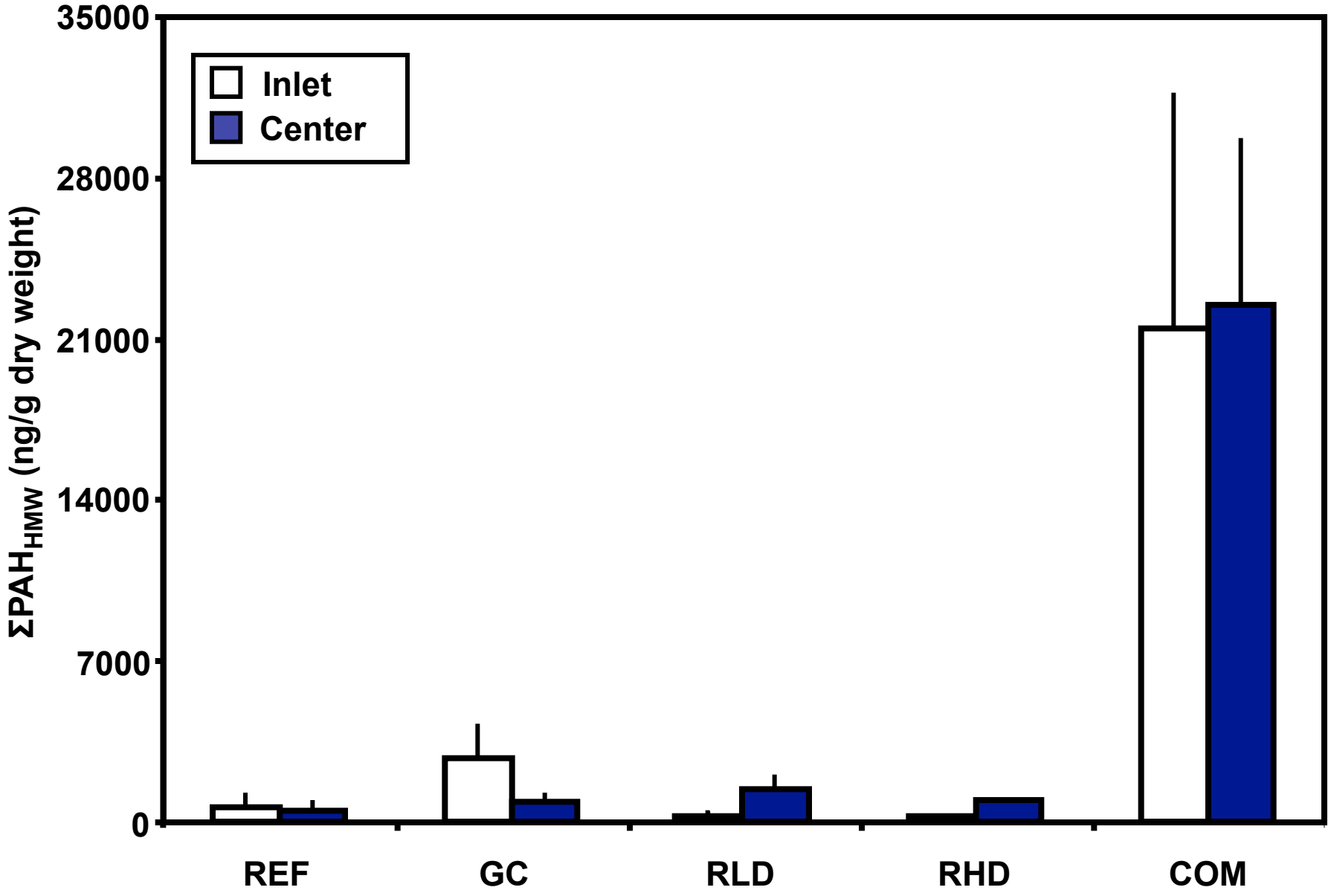
ΣPAH_{16}


40000
32000
24000
16000
8000
0
ΣPAH16 (ng/g dry weight)
Inlet
Center
REF
GC
RLD
RHD
COM

ΣPAH_{LMW}



ΣPAH_{HMW}

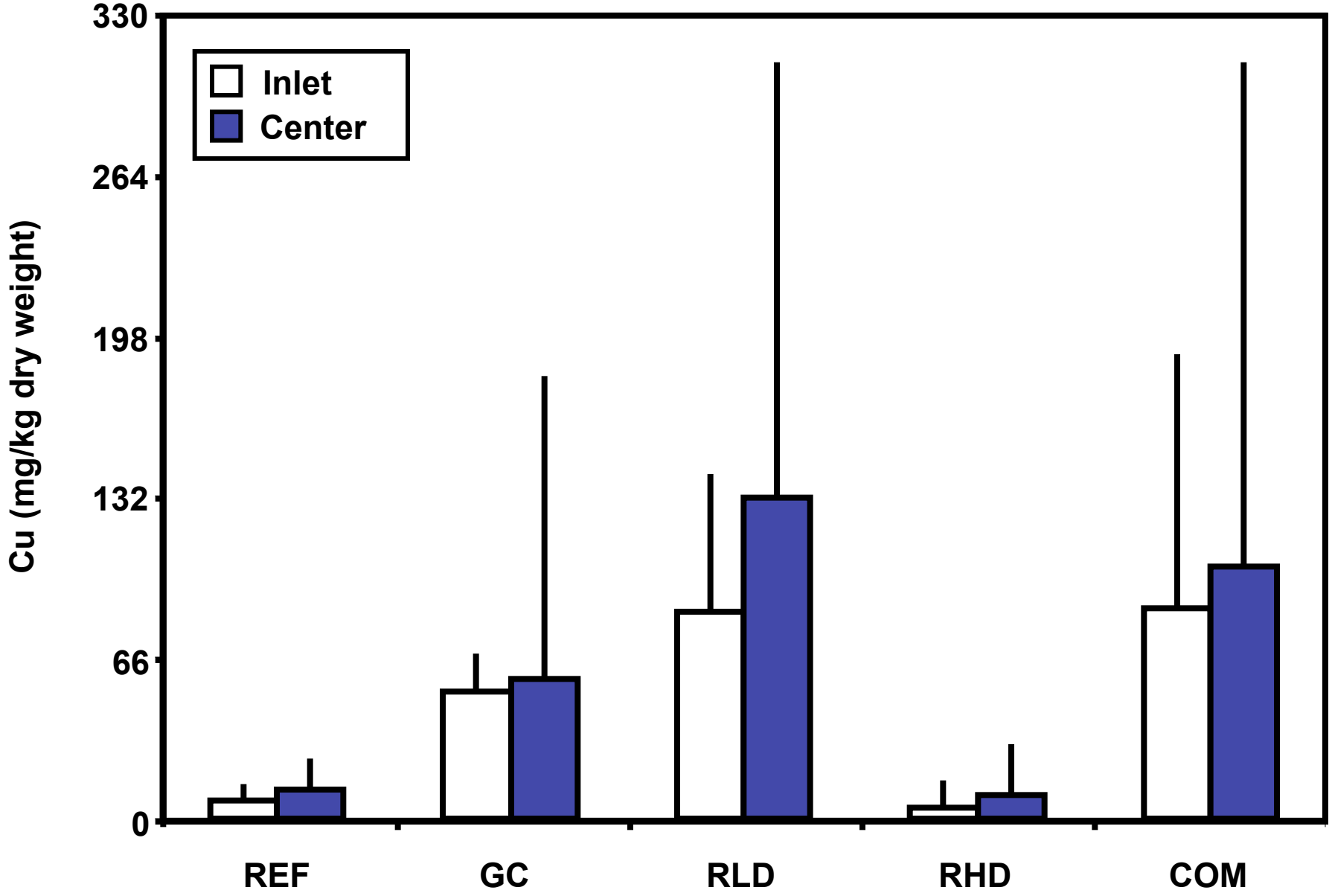


Metals

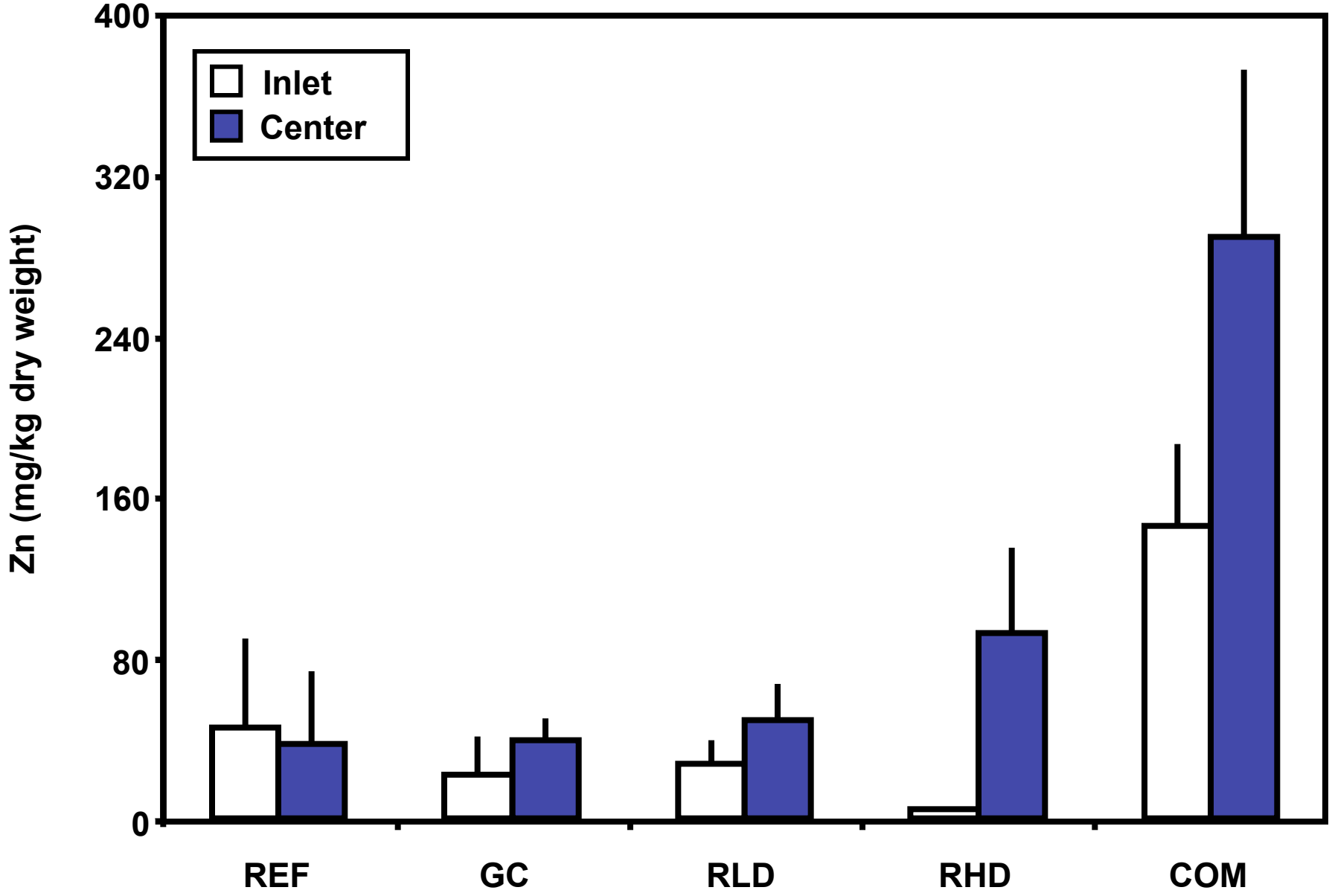
–Al, Cd, Cr, Cu, Fe, Pb, Zn

Cantebury Apartments, Myrtle Beach, SC

Copper


330
264
198
132
66
0
Cu (mg/kg dry weight)
Inlet
Center
REF
GC
RLD
RHD
COM

Zinc


400
320
240
160
80
0
Zn (mg/kg dry weight)
Inlet
Center
REF
GC
RLD
RHD
COM

Pesticides

- Chlorpyrifos was the most commonly detected pesticide
  - widely used on golf courses
  - banned from residential use in 2001
- Infrequently detected pesticides included chlordane, DDD/DDE, endosulfan, and dichlorvos

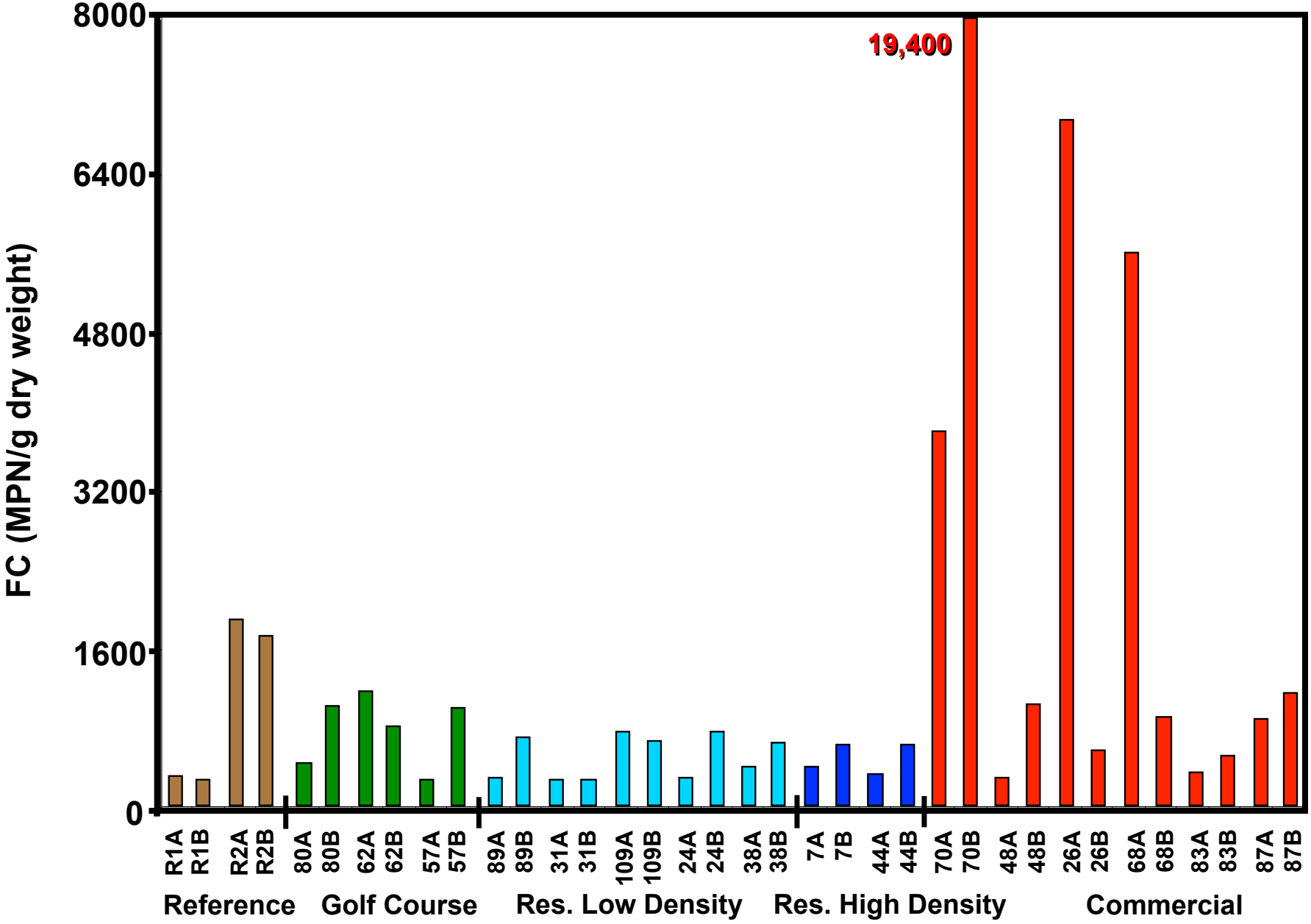
Ashton Glenn Subdivision, Surfside Beach, SC

Sediment Fecal Coliforms

- Commonly used as an indicator of fecal contamination (human and animal)
- Fecal coliform levels were generally similar to reference pond sediments

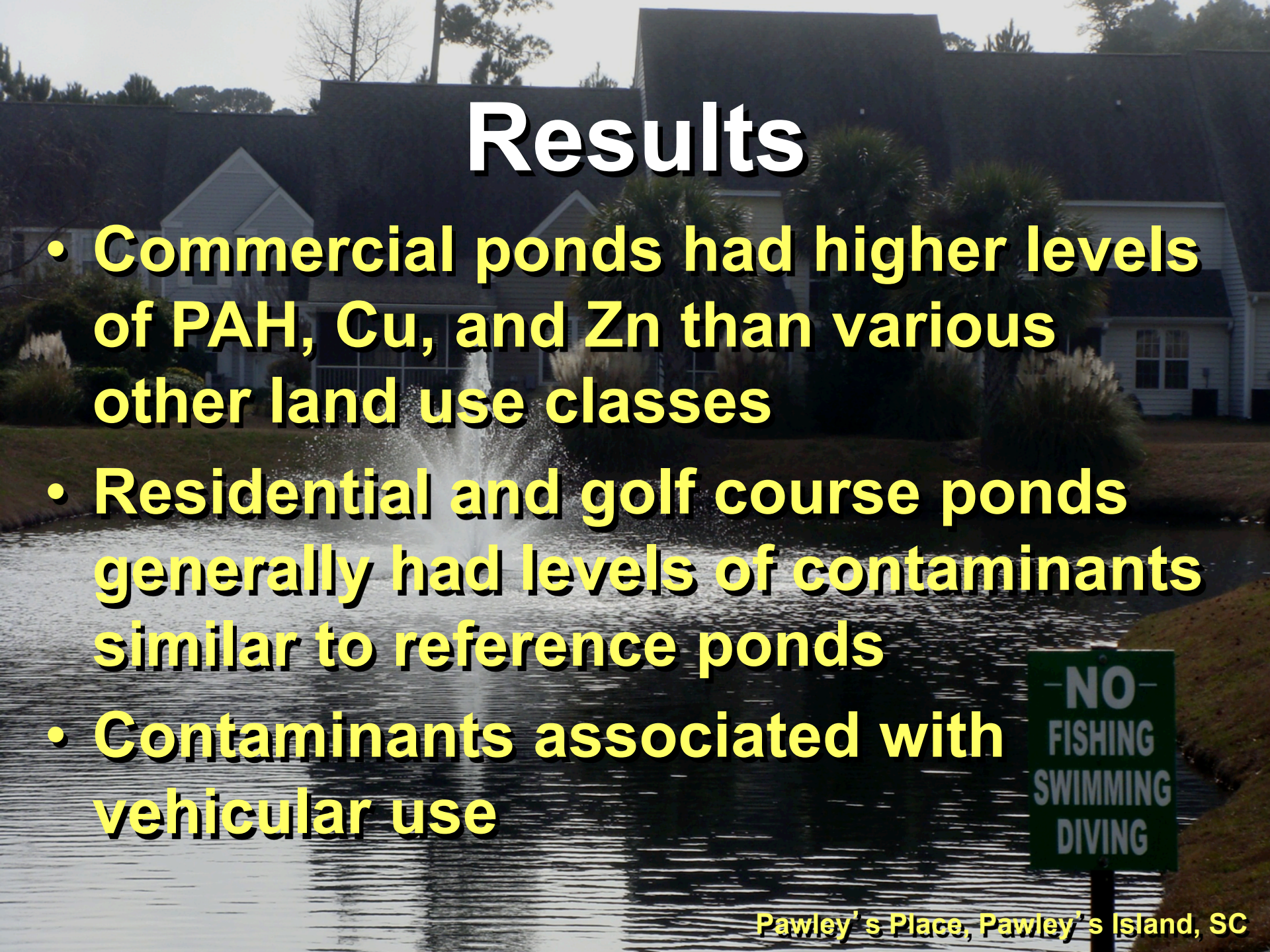
Cantebury Apartments, Myrtle Beach, SC

Sediment Fecal Coliform



Results

- Commercial ponds had higher levels of PAH, Cu, and Zn than various other land use classes
- Residential and golf course ponds generally had levels of contaminants similar to reference ponds
- Contaminants associated with vehicular use



Pawley's Place, Pawley's Island, SC

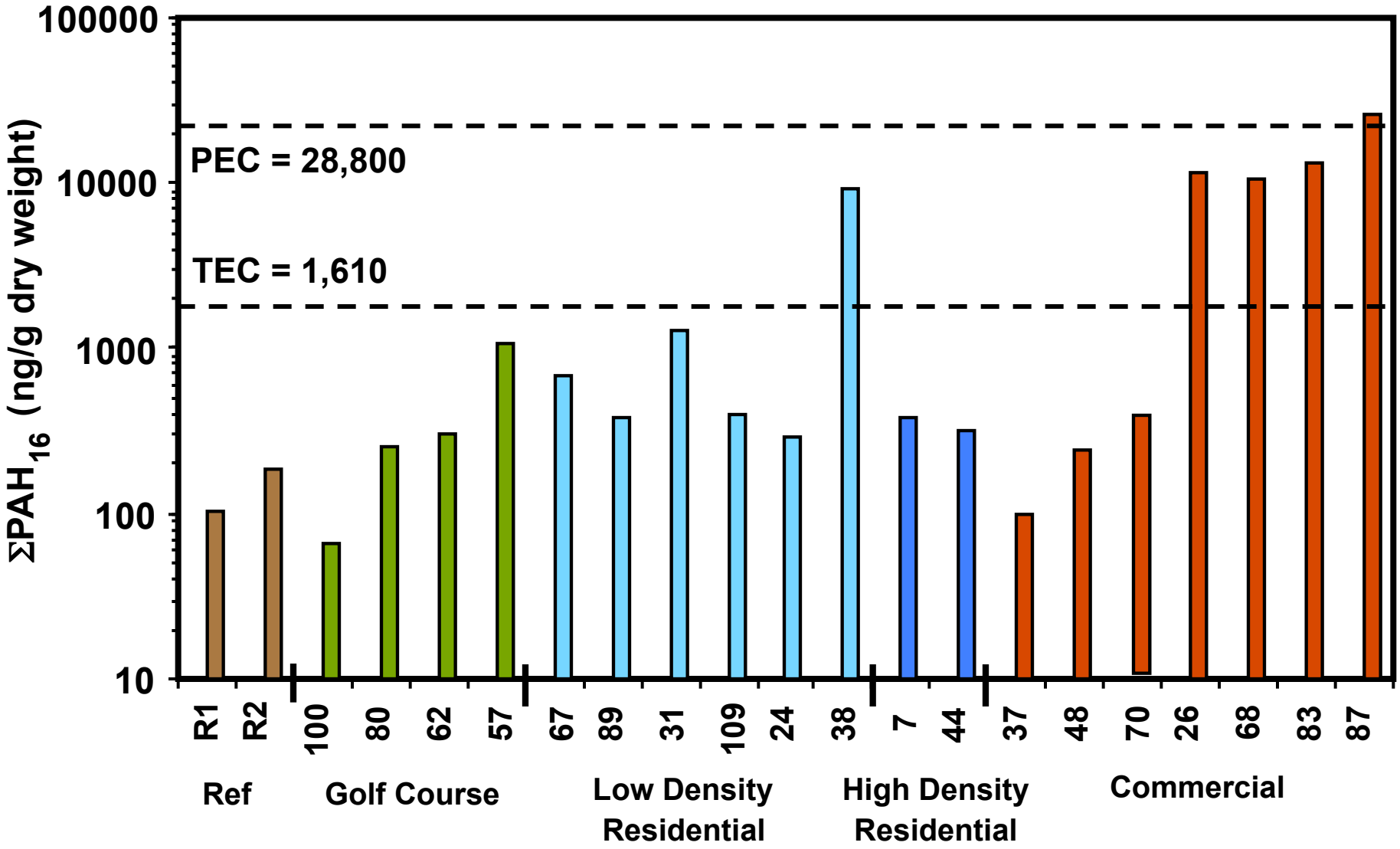
Screening Assessments

- **Ecological**
  - Consensus-Based Sediment Quality Guidelines (CB-SQC) (MacDonald *et al.*, 2000)
- **Human Health**
  - Regional Screening Levels (PRG) (USEPA, 2009)

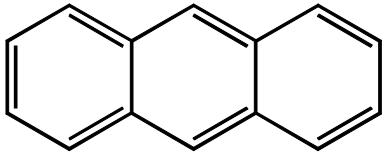
***In situ* vs. *ex situ* contact with sediments**

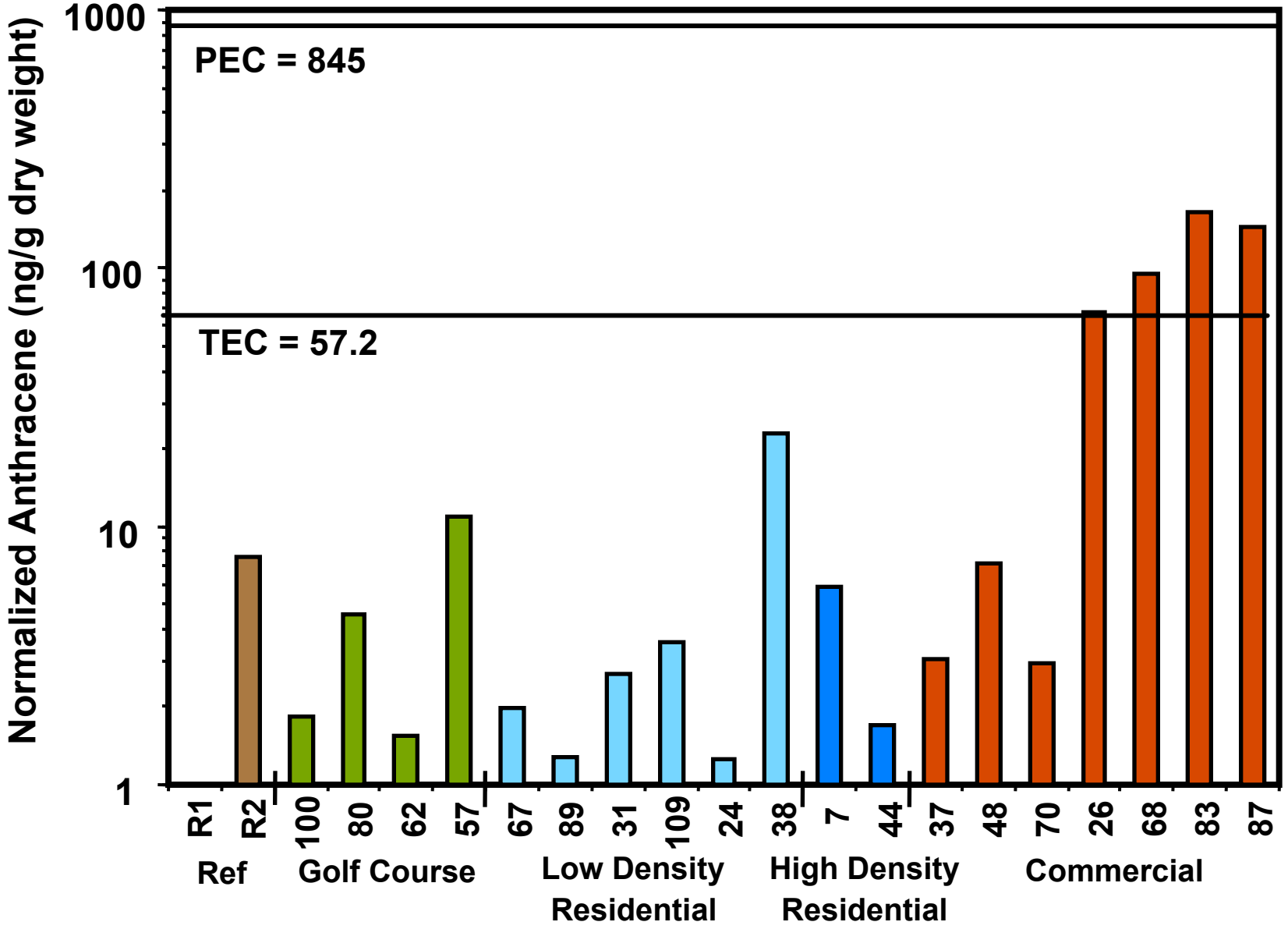
Cantebury Apartments, Myrtle Beach, SC

CB-SQG – ΣPAH_{16}

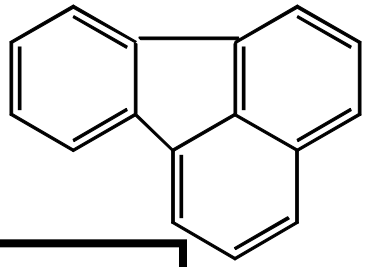


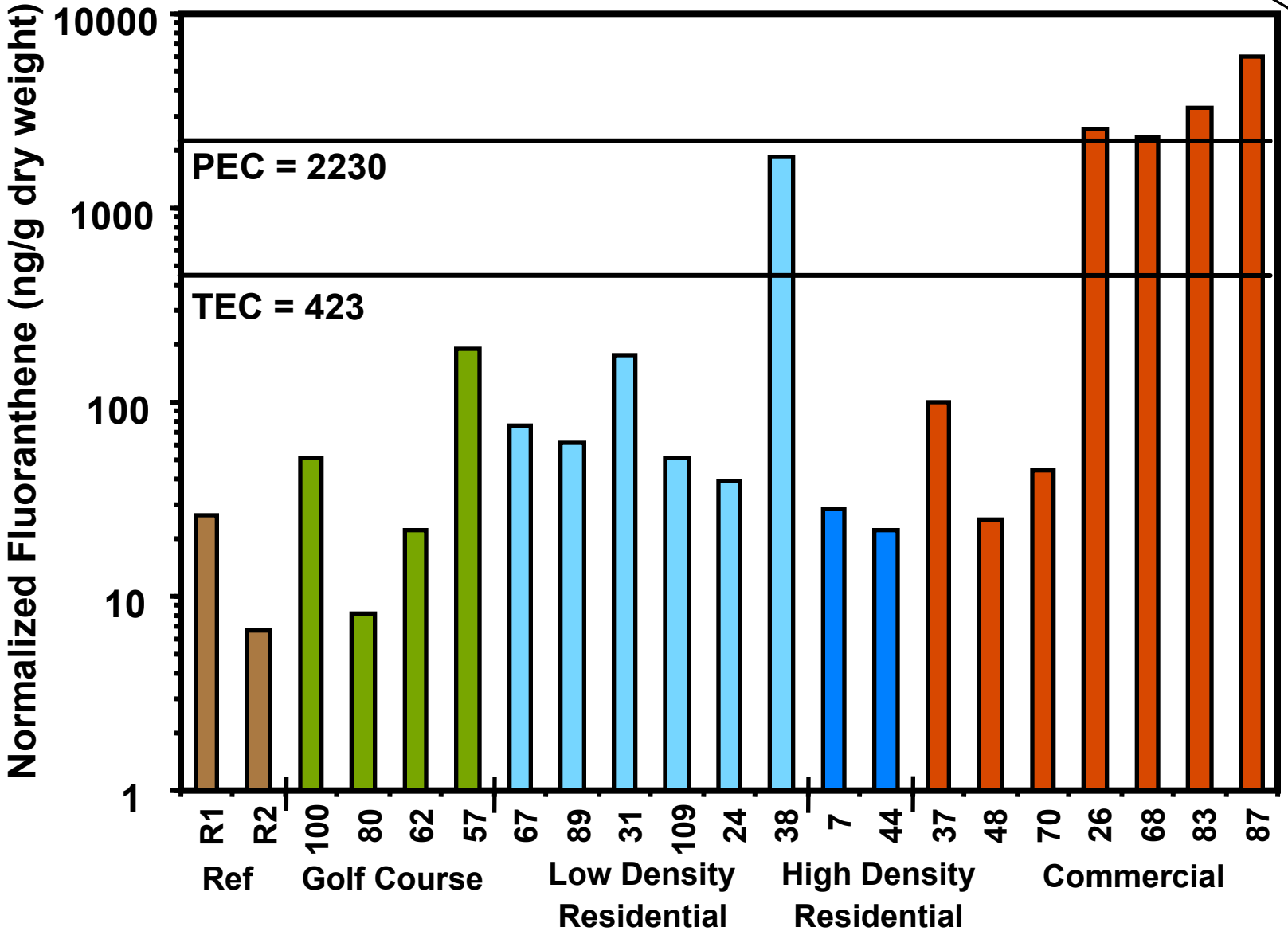
CB-SQG – Anthracene



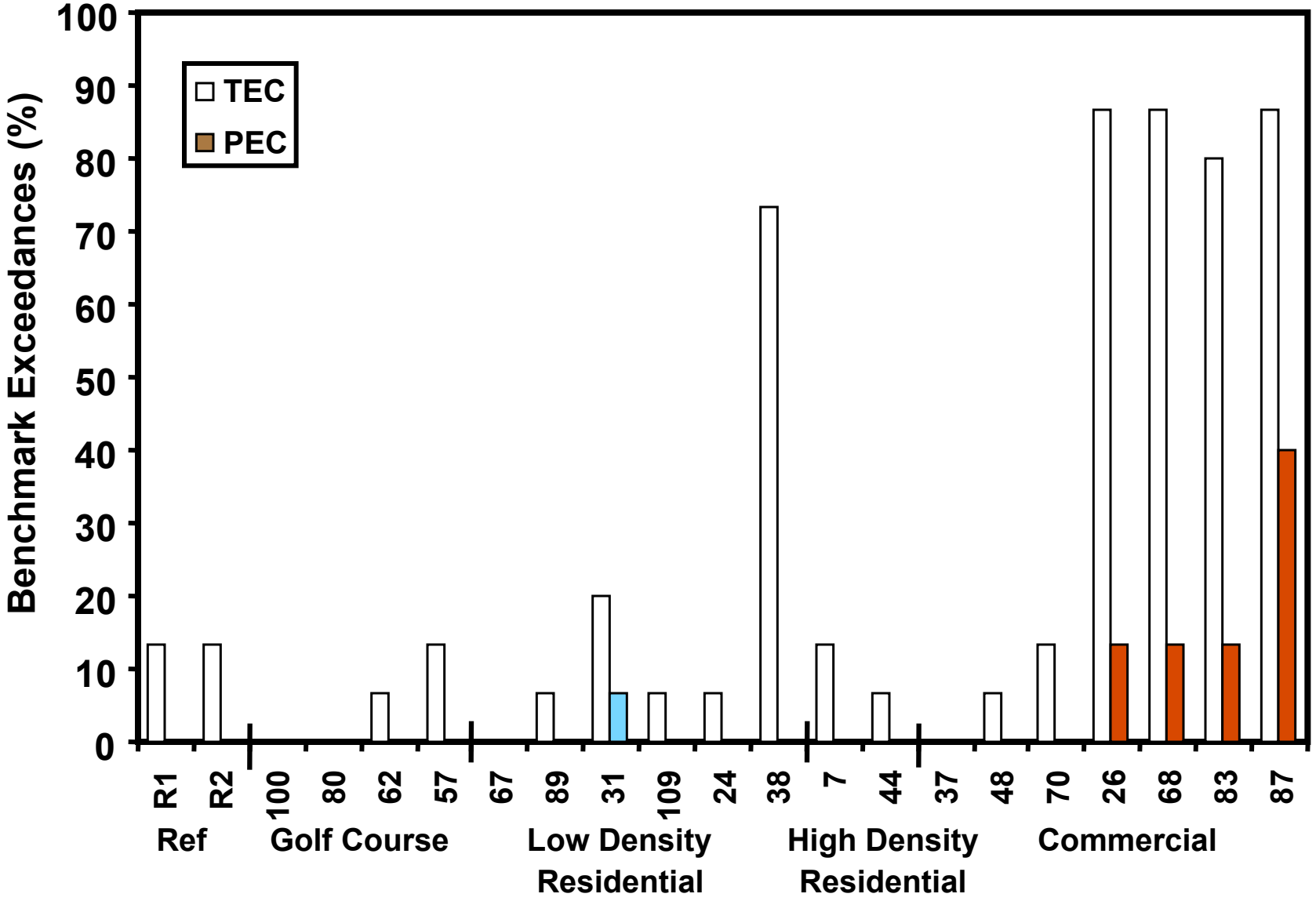


CB-SQG – Fluoranthene

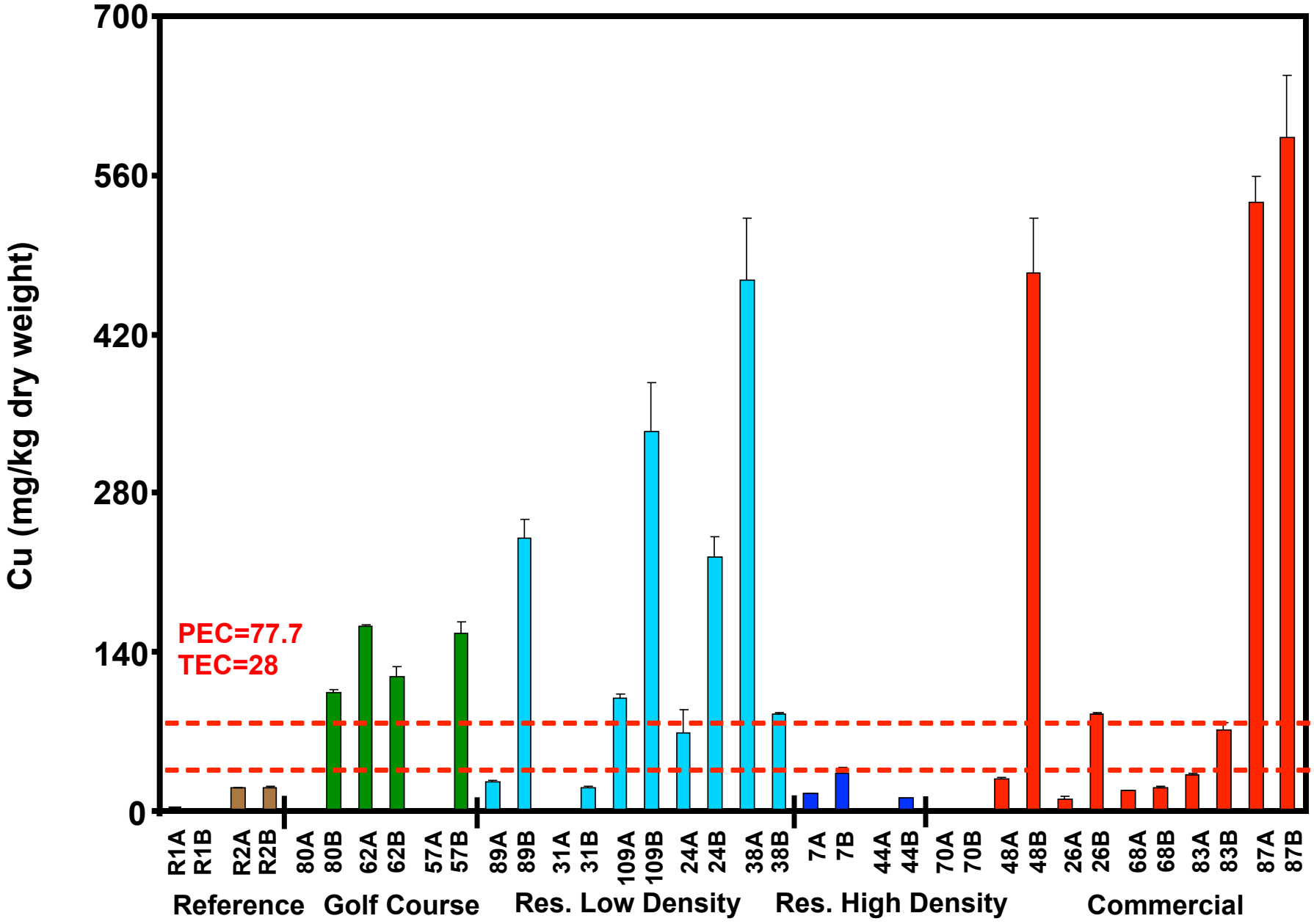




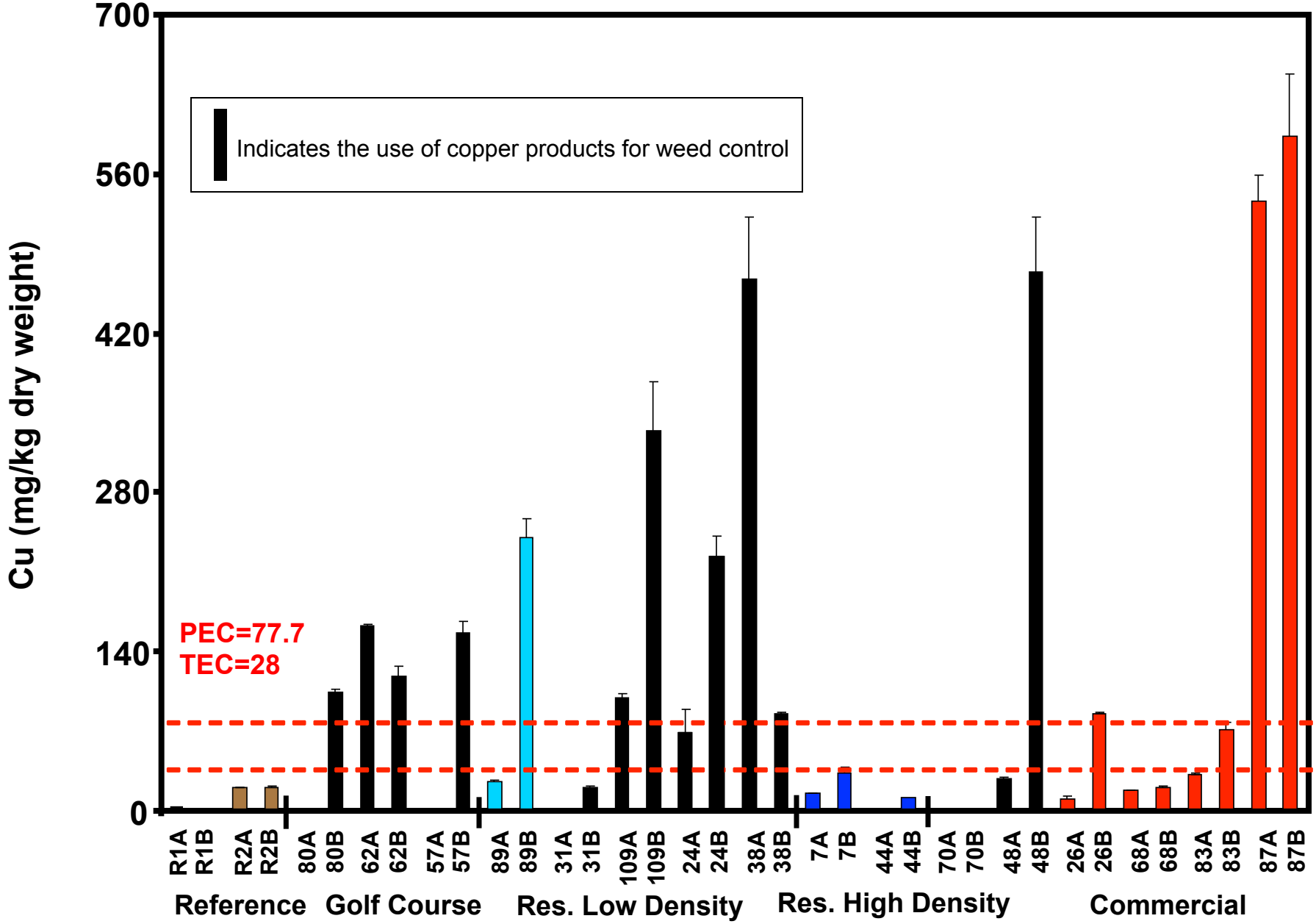
CB-SQG – Summary



Copper


700
560
420
280
140
0
Cu (mg/kg dry weight)
PEC=77.7
TEC=28
R1A
R1B
R2A
R2B
80A
80B
62A
62B
57A
57B
89A
89B
31A
31B
109A
109B
24A
24B
38A
38B
7A
7B
44A
44B
70A
70B
48A
48B
26A
26B
68A
68B
83A
83B
87A
87B
Reference
Golf Course
Res. Low Density
Res. High Density
Commercial

Copper


Indicates the use of copper products for weed control
Cu (mg/kg dry weight)
700
560
420
280
140
0
PEC=77.7
TEC=28
R1A
R1B
R2A
R2B
80A
80B
62A
62B
57A
57B
89A
89B
31A
31B
109A
109B
24A
24B
38A
38B
7A
7B
44A
44B
70A
70B
48A
48B
26A
26B
68A
68B
83A
83B
87A
87B
Reference
Golf Course
Res. Low Density
Res. High Density
Commercial

Results – Ecological Screening Assessment

- PAHs are a contaminant of concern
- Commercial pond sediments exceeded the TEC values for most individual analytes
- Benthic organisms have a low/moderate risk of adverse effects resulting from *in situ* exposure to PAHs in commercial pond sediments
  - Risk is higher in Pond 87
- Copper is also a contaminant of concern

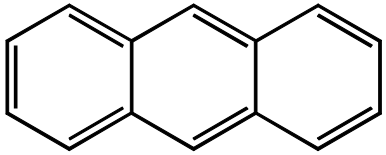
NASCAR Cafe, Myrtle Beach, SC

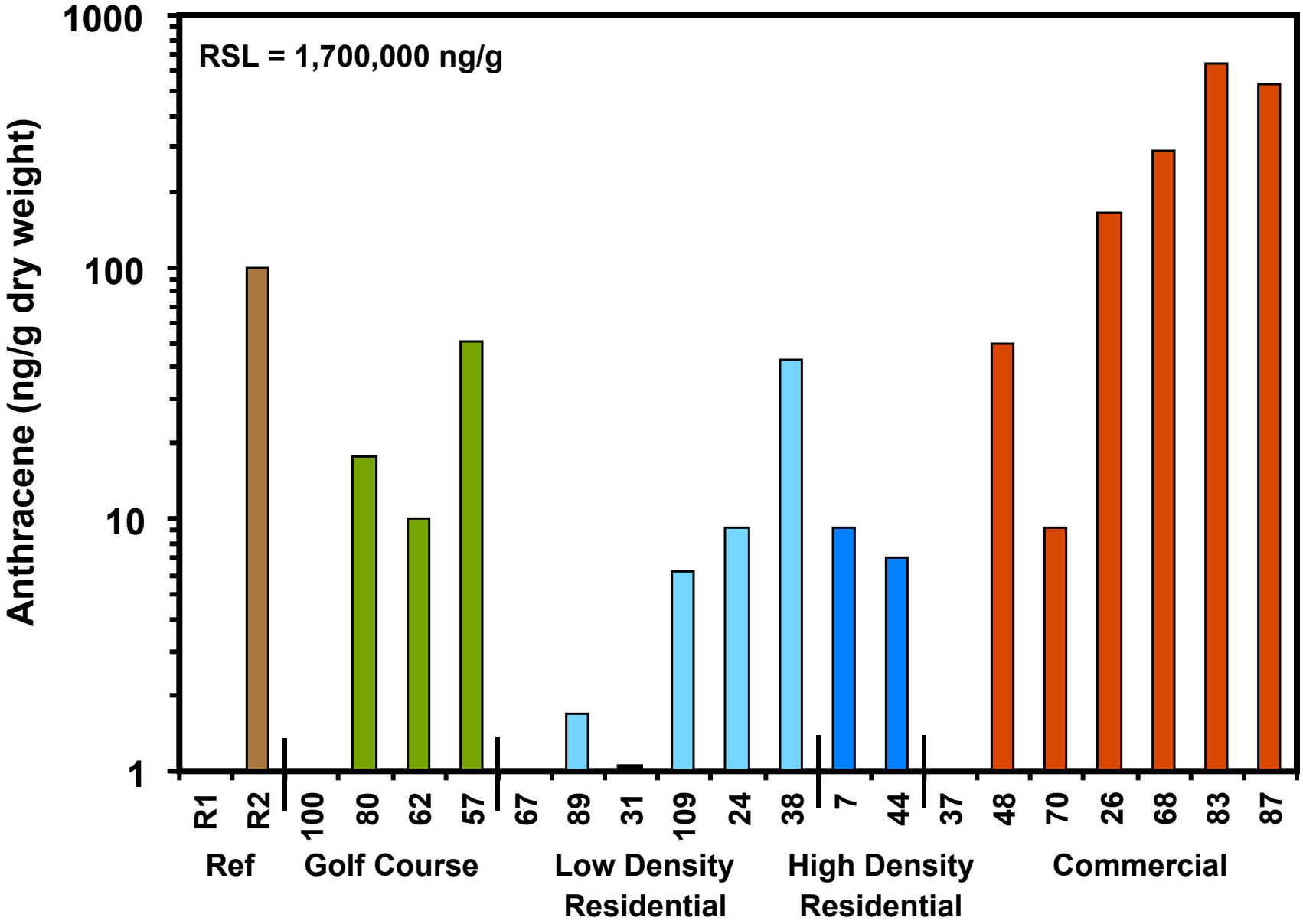
Human Health Screening Assessment

- Regional Screening Levels
  - Preliminary Remediation Goals (PRGs)
  - EPA Region IV and State of SC for residential soil limits
- Human health toxicity values combined with standard exposure factors
- Protective of human health following a lifetime of exposure

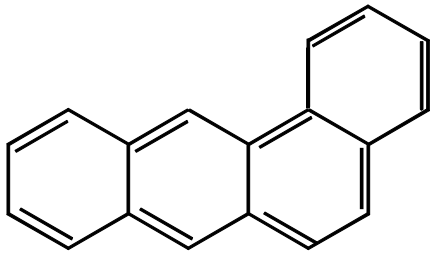
Ashton Glenn Subdivision, Surfside Beach, SC

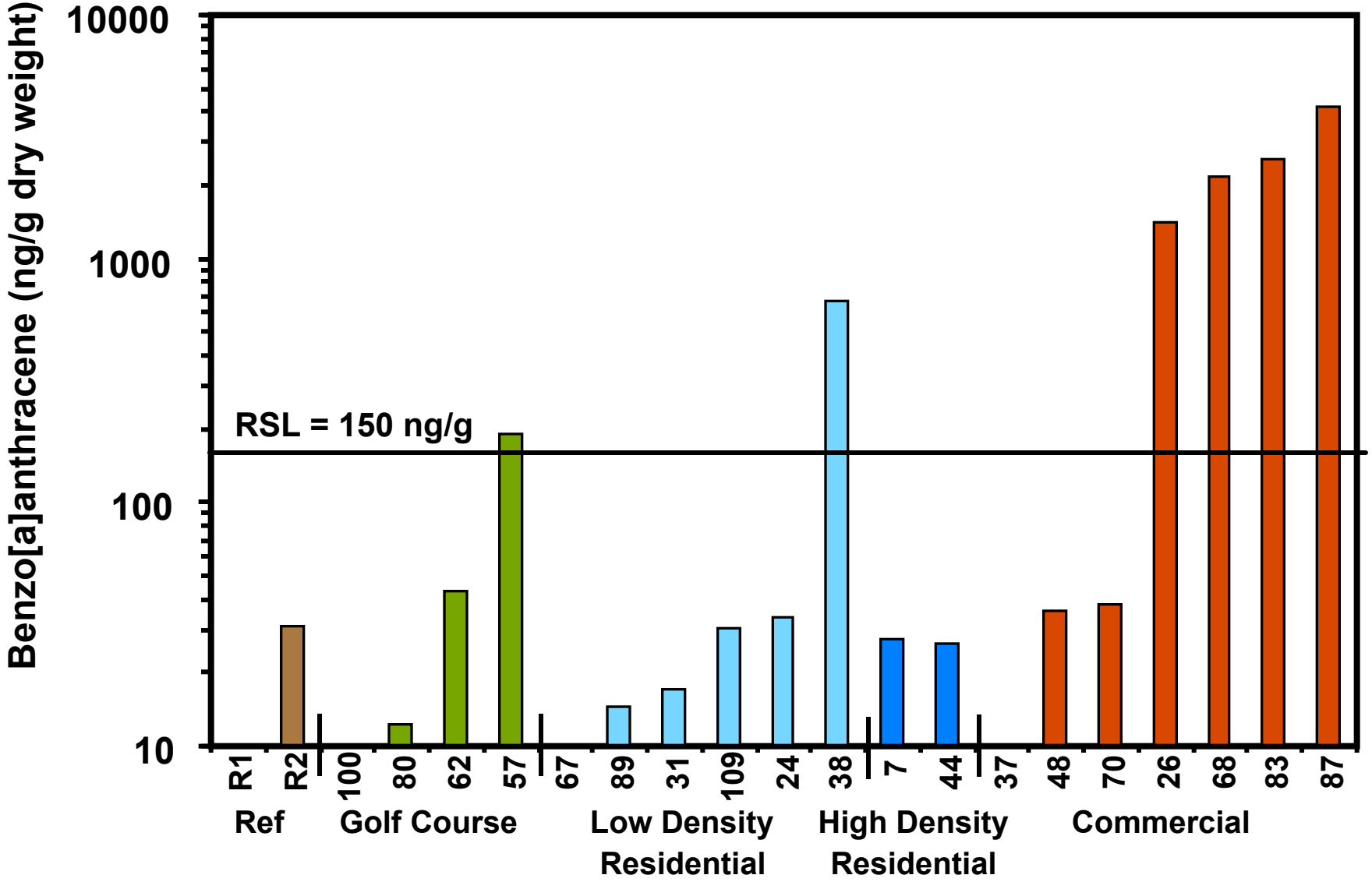
RSL - Anthracene



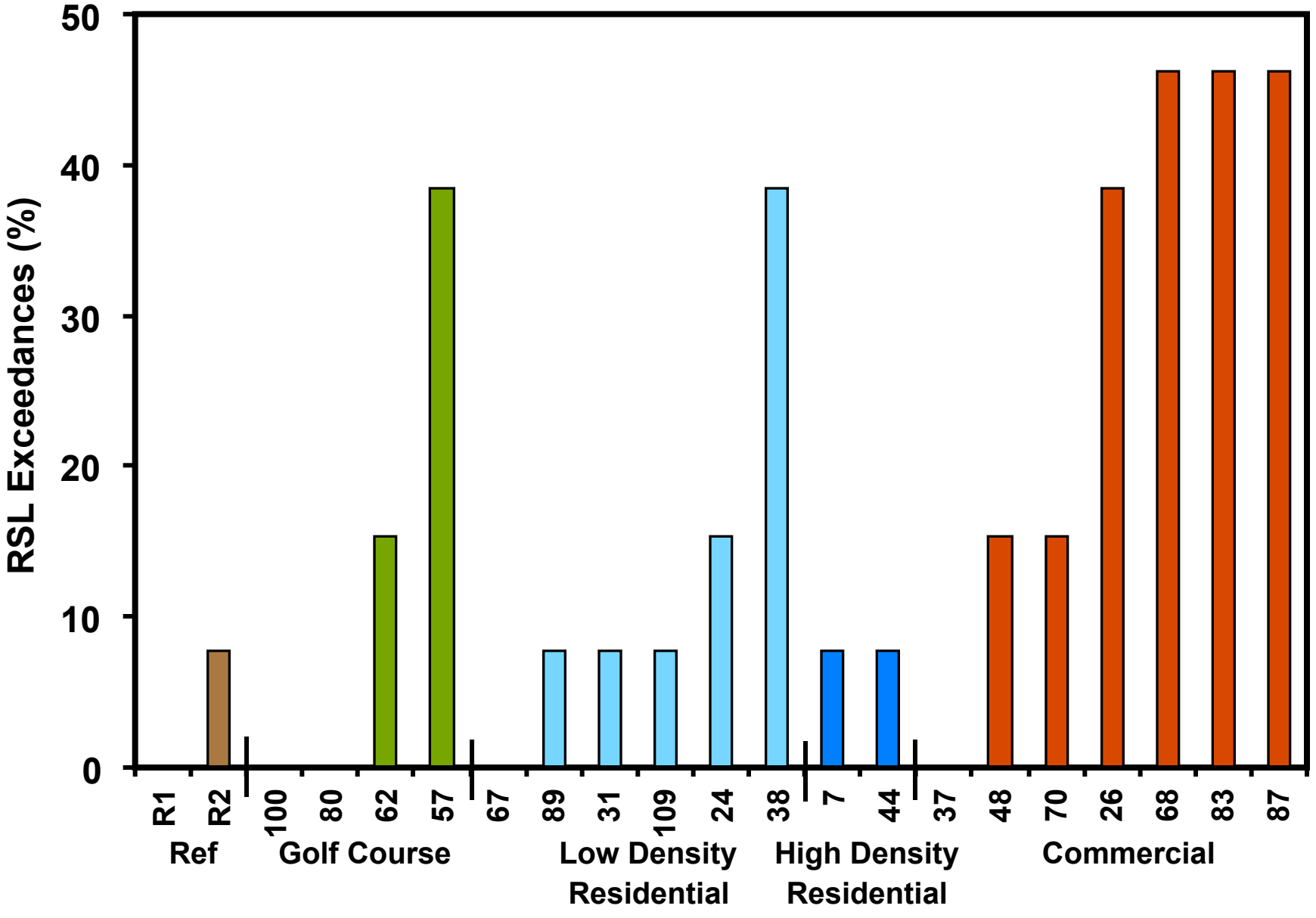


RSL – Benzo[a]anthracene





RSL – Summary


RSL Exceedances (%)
50
40
30
20
10
0
R1
R2
100
80
62
57
67
89
31
109
24
38
7
44
37
48
70
26
68
83
87
Ref
Golf Course
Low Density Residential
High Density Residential
Commercial

Results – Human Health Screening Assessment

- PAHs are a contaminant of human health concern in several commercial ponds
  - Sediments exceeded RSL values for several carcinogenic PAHs
  - Excavated sediment would not meet guidelines for on-site disposal in several states

Toys R Us, Myrtle Beach, SC

Other Considerations

- Age of the pond
  - Evidence suggests that sediment PAH levels increase with age
- Frequency of sediment excavation
  - Periodic excavation is not occurring as recommended
- Coal tar-based sealcoats

Ashton Glenn Subdivision, Surfside Beach, SC

Studies: Health risk from toxic pavement sealant greater than previously believed

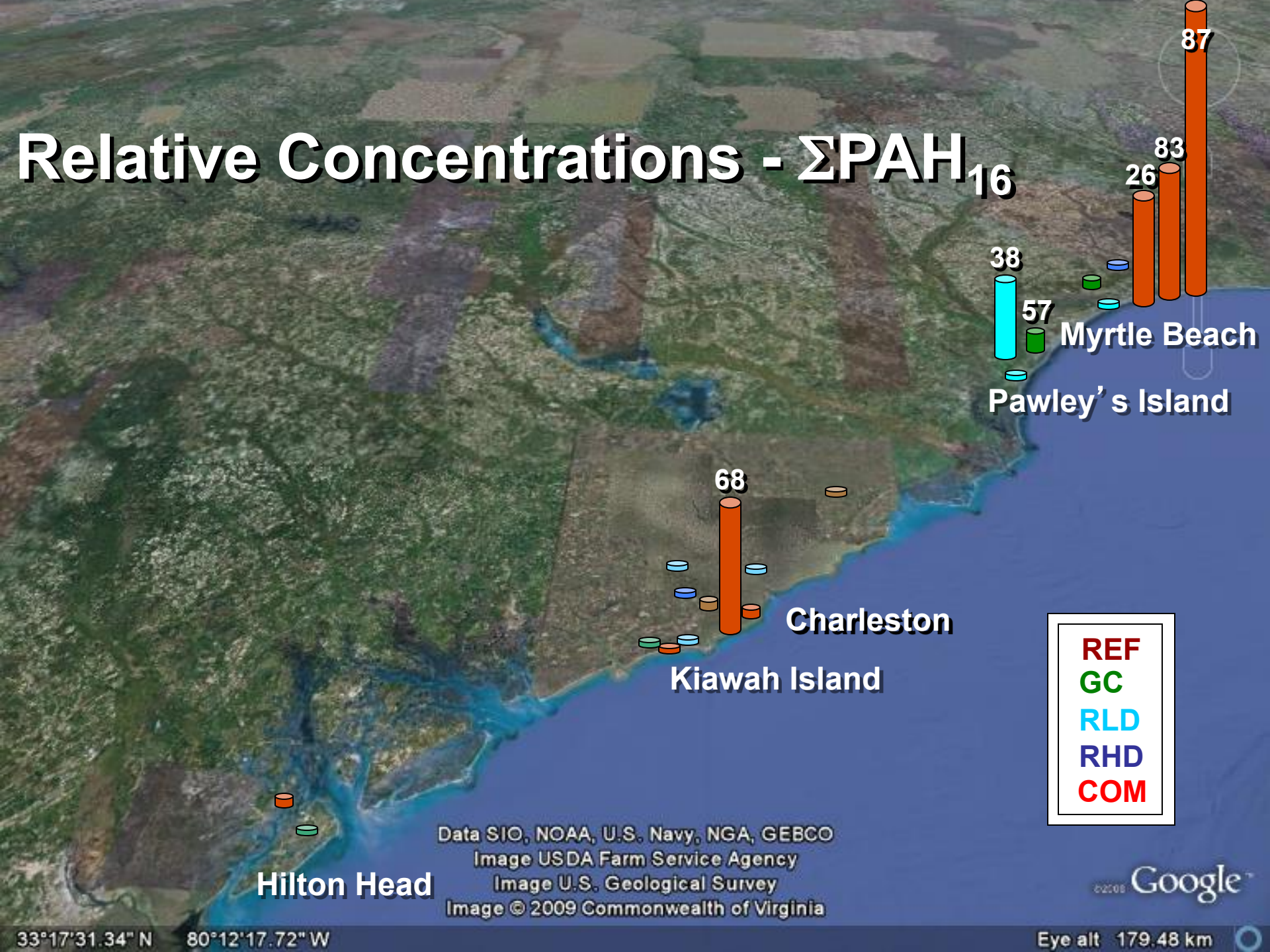
http://openchannel.msnbc.msn.com

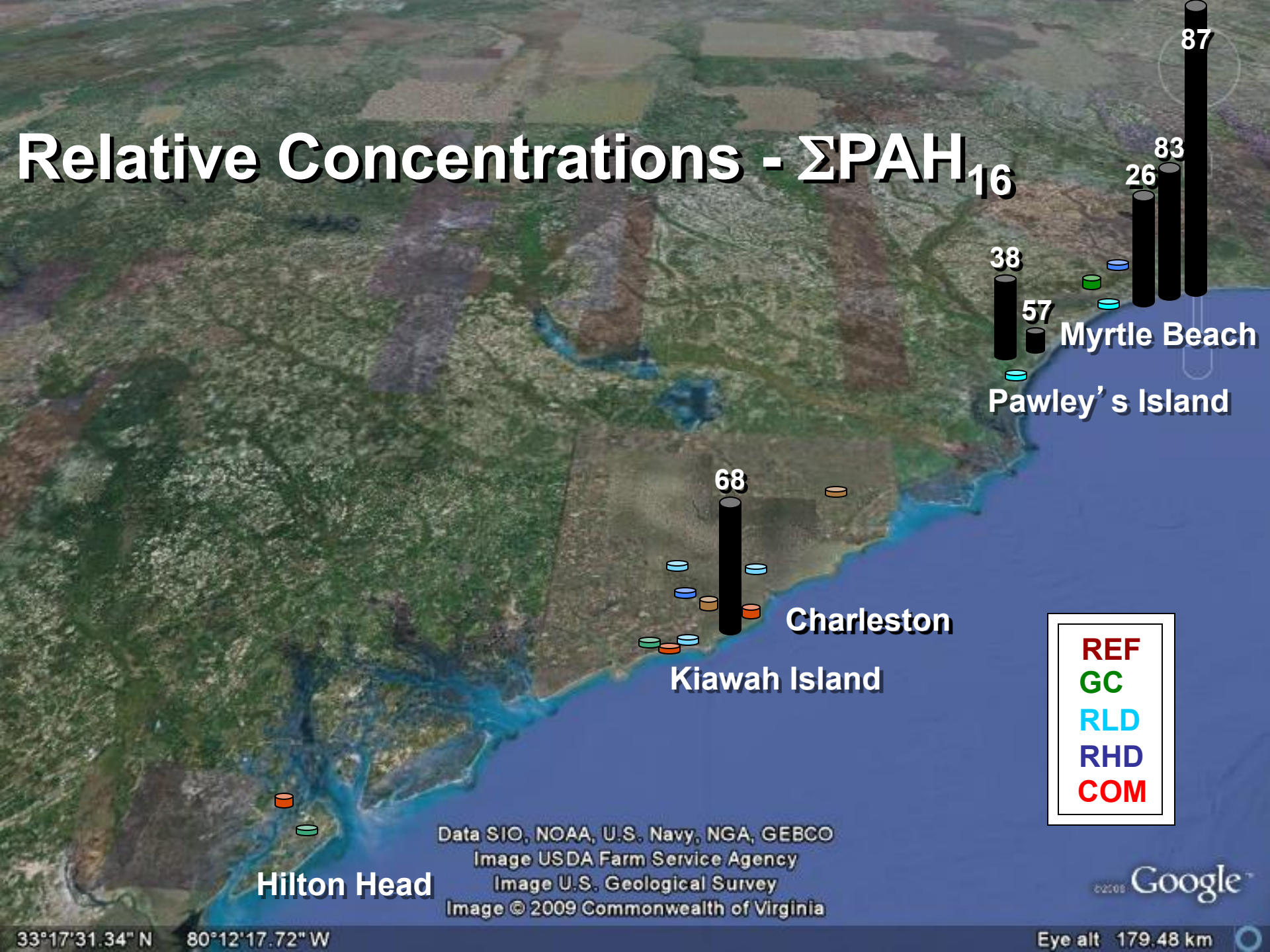
Evidence of Recent Seal Coat Use

NASCAR Café, Myrtle Beach, SC

Toys R Us, Myrtle Beach, SC

Ricefields, Pawley's Island, SC


Relative Concentrations - ΣPAH16
87
83
26
38
57
Myrtle Beach
Pawley's Island
68
Charleston
Kiawah Island
REF
GC
RLD
RHD
COM
Hilton Head
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image USDA Farm Service Agency
Image U.S. Geological Survey
Image © 2009 Commonwealth of Virginia
Google
33°17'31.34" N
80°12'17.72" W
Eye alt 179.48 km


Relative Concentrations - ΣPAH16
87
83
26
38
57
Myrtle Beach
Pawley's Island
68
Charleston
Kiawah Island
REF
GC
RLD
RHD
COM
Hilton Head
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Conclusions

- PAHs are a contaminant of concern in commercial ponds
- Benthic organisms – low/moderate risk *in situ*
- Humans – increased cancer risk *ex situ*
- Periodic excavation and restrictions on the use of coal tar-based sealcoats should reduce risks to both wildlife and humans

Tanger Outlets, Bluffton, SC

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  - Mark Messersmith
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- The Citadel Foundation
- Students
  - Gavin Globensky, Colby Swank, Leigh Thackston, and Kyle Williams

Further Information…

- SC DHEC/SC Sea Grant Final Project Report
  - www.scseagrant.org/pdf_files/SC_stormwater_rpt.pdf
- Stormwater
  - http://www.stormh2o.com/july-august-2010/sediment-contamination-detentionponds.aspx